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Effects of Viewing Condition on User Experience of Panoramic Video.

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Abstract

Panoramic video arises at the convergence of TV and virtual reality, and it is necessary to understand how these technologies interact to affect user experience in order to produce useful content. TV and film makers have developed a sophisticated language and set of techniques to achieve directed linear story telling on fixed screens, whereas virtual worlds more often emphasise user led exploration of possibly non-linear narrative and aspects such as presence and immersion in navigable 3D environments. This study focused on the user experience of panoramic video as viewed over two conditions, on a VR headset and using a handheld phone, and compared this to watching on a static screen thus emphasising the differences between traditional and panoramic TV. A qualitative approach to analysis was taken where users participated in semi-structured interviews. A thematic analysis was performed which produced thematic maps describing user experience for each condition. A detailed and nuanced account of emerging themes is given. Subsequently, key themes were identified and graphed to produce user response profiles to the three viewing conditions that highlight differences in user experience in terms of presence, attention, engagement, concentration on story, certainty, comfort and social ease.

Categories and Subject Descriptors (according to ACM CCS): H.1.2 [User/Machine Systems]: Human factors—

1. Introduction

In tandem with the advent of consumer level Virtual Reality (VR) heralded by devices such as the Oculus Rift, the HTC Vive headset and Google Cardboard, there has been a rise in the production and consumption of panoramic video (or 360 degree video as it is more widely becoming known. We use the term 360 degree video interchangeably with panoramic video). The provision of hardware for the production of such video has rapidly developed from ad hoc solutions using multiple individual cameras with custom rigs, such as the Freedom 360 mount, to dedicated consumer level cameras like the Theta and Samsung Gear 360 panoramic cameras amongst many others. Similarly software for processing and stitching multiple video sources is moving from expensive third party software to bundled easy to use solutions. At the same time, media producers such as the Associated Press, the New York Times, and others have been starting to produce 360 content, whilst Hollywood companies have been investing in related areas.

1.1. Production and interpretation of panoramic video

Throughout the history of visual media the grammar and language of story telling through film and television has evolved with a consequent requirement on viewers to develop a sufficient literacy in order to consume such media. That consumption of such media

may be effortless for the modern viewer can be seen in the unthinking way viewers can understand editorial narrative and stylistic devices; for example such as the use of an establishing wide angled shot, followed by a close up of a main character. In real life (and it can be true for panoramic video) it would be disturbing to see a distant view of a car racing across the desert at one moment and then to be an instant later apparently inside the car looking at an angry woman driving, but the format of such a sequence is a trivially understood classic device in the traditional visual story telling repertoire.

Traditional film and television production involves the director dictating what the viewer can see at each moment of the film. However, such control is taken away in panoramic video where the user may look anywhere in the environment. Panoramic video then brings new challenges on both sides of the equation: how can content producers tell stories when they cannot control where the viewer is looking and established narrative devices may not work?, and how may viewers understand 360 media when they have control of their view and the visual media literacy they have learned may not be relevant to the new context? Thus many content creators are talking about struggling to find the new language for story telling in VR. Within this debate is also the question of genre; will some genres be better suited to the new medium than others?, and will new genres possibly emerge? Interestingly,

given the discussion of story above, many of the first examples of 360 video are largely (story free) experiences (such as sky-diving and other action sports) which 360 video brings a unique immersive perspective to. At the other end of the spectrum, we can see the possibility of the emergence of new genres, embodied, for example by “Gone” (<http://www.engadget.com/2015/12/04/gone-vr-thriller/>) the gaze based interactive 360 degree thriller series, in which the user is visually cued to look for signposted, visual clues in the 360 panoramic video; these can be selected and explored (by gaze) to yield extra clues (e.g. photospheres) in order to solve the thriller. In the current study, we consider a single character led video, in which the most important details are presented centrally in the 360 view, and for which the 360 panorama is used primarily to add to the immersive ambience of the piece.

1.2. Related work

VR has been in existence since the mid - late 1960’s in various forms. Panoramic video is a relative newcomer to the VR stable, but much of previous work in VR is relevant to it. Interaction with panoramic video is currently limited, although several studies have been carried out in relation to interaction such as panning and zooming into stored and live panoramic video [GLS*14] [IKFM10] [ZBEÖ13]. As panoramic video resides largely in the world of entertainment, we are interested in users’ level of engagement with it. According to Peters et al., in most studies of engagement there are two underlying fundamentals which are apparent, namely attentional and emotional involvement [PCdF09]. Engagement can manifest as a number of feelings or sensations experienced by people when engaging with a VE; these include phenomena such as presence, immersion, embodiment and agency. Presence, the sensation of actually ‘being there’ in the virtual world, is arguably the most researched phenomenon in relation to VR [LD06] [SSRF01] [SW97] [SvdSKvdM01]. More recently, there has been a focus on to what extent people respond realistically to the illusion of being in a place, place illusion, and experiencing/responding to events as if they were real, plausibility illusion [SSV14]. Also important is an understanding of Hall’s proxemics model which described interpersonal space, from intimate space to personal, social and public space [Hal69]; a model which is also pertinent in virtual worlds. We expect these factors to be relevant in the user experience of 360 video. However, we are sensitive to the idea that asking users directly about abstract concepts may be uninformative [Sla04], so we have used interviews in the first instance to allow viewers to express their opinions in their own language.

2. The Study

2.1. Aim and Experimental Conditions

The aim of the study was to compare the user experience of monoscopic 360 video viewed across three viewing platforms. An eight minute documentary profile of an artist, entitled “The Resistance of Honey” was used. The video is a character led study of the artists exploration of beekeeping, the recording of bees, and the subsequent production and performance of derived electronic music. (See figure 1 for a flyer or <http://vimeo.com/187148046> for



Figure 1: A flyer showing part of an equirectangular image from the Bee man video where he is making electronic music in his studio.

an online trailer) The three conditions which were used to view the 360 degree video in the study used either a Samsung Gear VR Headset (using a Samsung Note 4 phone at Middlesex University and a Samsung S6 phone at both BBC sites) hereafter referred to as the headset condition; or a handheld Samsung Note 4 or Samsung S6 phone, hereafter referred to as the phone condition; or a Mac-Book pro 17 screen hereafter referred to as the screen condition. For the headset condition, the viewer could change their view simply by moving their head. For the phone condition, subjects could change the view either by moving the phone around in 360 degrees or by swiping to change the view. For the screen condition, the central twenty five percent of the video was extracted from the equirectangular video to approximate a typical 16:9 view, and was displayed on a static monitor.

2.2. Subjects

The study was carried out with 24 participants comprising 13 male and 11 female subjects in the age range of 22 to 42. The study drew subjects approximately evenly from Middlesex University (13 subjects) and two BBC sites (11 subjects). To keep the length of the experiment manageable, each subject viewed the video twice over two viewing conditions, and the order of viewing for any two conditions was alternated per subject to counter any order effects. We thus had 3 groups of 8 subjects who compared either headset and phone, headset and screen, or phone and screen viewing conditions. Subjects had varying degrees of experience with VR devices, from none, to having tried a range of devices.

2.3. Procedure

Subjects were first shown a short panoramic video clip about London’s Chinatown to orient them to the task and to familiarise them with navigation mechanisms as appropriate. Subjects then viewed the main video using their assigned viewing mode. Following this, a semi-structured interview was used to elicit conversation about

the viewing experience. Guideline questions that could be used in the interview included:

- How do/did you feel after/while watching the video?
- Did you find any differences to 'normal' videos that you watch on your phone, PC or TV?
- What's good about watching videos this way? What's bad about watching videos this way?
- Can you recall any moments that made you feel inclined to look around more?
- How much did the video hold your attention or focus?

These questions were the same for each participant and allowed expansion on replies of interest. The participants were video recorded and observed throughout the study. Following the second viewing and interview, the participant was asked to complete six questions in the form of a Likert scale for each condition undertaken. The questions referred to the participant's experience in relation to the device used. The subjects were asked:

Please circle the number; from 1 (not at all) to 5 (very much), that best matches your response to each statement.

During my experience of the displayed environment...

- I felt like I was there, in the scenes of the video.
- I felt I could interact with the displayed environment.
- I paid more attention to the displayed environment than I did to my own thoughts (e.g., personal preoccupations, daydreams etc.).
- I felt as though I was in the same space as the character and/or objects.
- How much did you enjoy the content of the clip?
- How much did you enjoy the way you viewed the clip?

The general procedure was thus: users completed a pre-trial consent form, underwent orientation for the first platform, the user watched the documentary using the first platform, was interviewed about the first platform, underwent orientation for the second platform, the user watched the documentary using the second platform, was interviewed on the second platform, finally the user completed the Likert scale questionnaire for each platform.

3. Results

3.1. Thematic Analysis

The Thematic Analysis methodology, as described by Braun and Clarke [BC06], was followed. The analysis of the study began with transcriptions of each interview using the video recording. Following this, Nvivo 10, a qualitative data analysis computer software package, was used to facilitate thematic analysis of the transcribed interviews. Each transcription was scrutinised and coded using open coding. While reading the text, a 'node' (as it is termed in Nvivo) or theme, was created and separate words and/or sentences were assigned to the node. The nodes were created spontaneously according to the judgement of one of the authors and refined and modified during the coding process. Subsequent words or sentences were allocated to the newly formed nodes, with new nodes created as and when the author felt needed.

Once completed, the initial coding, which included forty nine

themes, was reviewed by the other researchers. The majority of nodes used, and the allocation of words to those nodes, were agreed upon and some minor discrepancies resolved. Using Nvivo 10, each transcript was coded both with the themes designated by the researchers and also by the viewing condition headset, phone, or screen. The themes identified were reviewed, in some cases amalgamated, and then clustered into universal themes. Because of the way that the transcripts had been coded, it was easy using Nvivo to ascertain the frequency with which a node was coded for a particular condition and to access the actual text which was coded in the transcriptions. This enabled the researchers to analyse nodes in relation to the viewing conditions and to check back from themes to transcripts. Following this analysis and the identification of prominent nodes, a number of recurring themes were identified. Twenty one large thematic maps were then created, one per viewing condition per category. These were then amalgamated into single thematic maps per condition and then distilled down to the key themes identified in this report.

3.2. Presence and Disembodiment

Half of the users (8 out of 16) who completed the headset condition alluded to the concept of presence by talking about feeling embedded in the video or being with the Bee man (the character in the video) etc. This was quite a strong result that was backed up by the responses to the questionnaire questions related to presence. The interview questions did not specifically mention presence and the questionnaire question related to presence was only asked at the end of both viewing sessions so as to not lead viewers. One viewer said "*I felt I was there with that person...*" and "*... gives you ... sense of being a part of it rather than just watching ...*" For the phone condition this was much weaker, only two subjects comments were coded under presence one was very positive: "*You feel like you are there.*" while the other commented on the lack of presence in comparison to viewing with the headset: "*I don't feel so much in that environment.*"

A number of users specifically talked about the experience as either being immersive or more immersive than either the phone or screen conditions for the headset condition, or more immersive than the screen condition for the phone condition. For example for the headset condition: "*It was interesting to feel like you were that person changing the music around or actually doing that action ...*" or for the phone condition: "*I think it's a lot more immersive [than the normal way of watching video].*"

For the headset condition, some users positively reported feeling close to the Bee man, and located in the same environment or scene: "*One shot was close to him and it was good to be able to look down to see what he did.*" The shot being referred to here was of particular interest in this study. In the Bee man's studio there was a point where the Bee man is sitting at a table and producing music by adjusting potentiometers and the like on electronic circuits that had components and wires exposed. The shot was taken with the camera placed between the Bee man's face and his hands. This shot was within the zone of intimate or personal space as described by [Hal69], which is not normally perceived neutrally and may be threatening. However some viewers particularly liked this view with one viewer saying that she felt like she was actually mak-

ing the music. Others reported this closeness as being a negative experience. *"The Bee man was kind of odd"* and *"I turned around and then suddenly the Bee man just appeared in strange clothing. It felt sinister."* Closeness to the screen was uncomfortable for some users *"being up close to a screen.. you don't blink as much your eyes don't feel as comfortable afterwards"* and *"it's like something you could get addicted to.. which probably isn't too good for you as your so close to the screen."* The nearest theme to closeness for the phone condition was discussion of a Sense of Space: *"because it's a voice over I think it's much more successful because it gives you that space to kind of explore."*

Many users described the experience as engaging e.g. for the headset condition: *"it's around you so you have to focus on it, it's around you so in that sense it's much more engaging"* and *"it just engages you with what you are watching more"* and *"I'm more engaged emotionally, so to speak."* Similarly for the phone condition: *"I think it's a lot more immersive, or interactive, in a sense that it's more engaging."*

Although the user's agency was limited to being able to choose where to look, some users commented particularly on the interactive nature of the viewing experience which does indeed distinguish it from a normal screen viewing experience (for the headset condition it was being able to look around by turning the head). For the phone, it was the ability to look around by moving the phone or swiping. However, for this condition, previous interaction with phones led to some unfulfilled expectations: *"I would like the option to zoom..."* and *"if I can swipe, can I do this as well? [zoom]."*

For the headset condition, some users were upset by the lack of any reference to their own bodies in the video, and some talked specifically about not being able to see their legs when they looked down: *"It feels like an out of body experience"* and *"It's weird looking down and you can't see your legs."*

For the phone condition it was also a mixed experience. While there were many positives; some users found it more immersive than normal, more fun, could see more of what is happening around and: *"Thought it really added to the film."* There were also many negatives: the screen was too small, it was tiring moving the phone around, users could not zoom and one user reported: *"... a weird separation from content ..."*

3.3. Focus and Attention

For the headset condition, some users reported a positive effect as not being distracted by external stimuli as one might normally otherwise be: *"the headset really concentrates your mind so you're not distracted by anything else"* and *"if I was at home I'd get distracted by kids etc. but when you're shut away you've got no option it's around you so you have to focus on it."* However, others reported that looking around was distracting because there was so much to see: *"It can be distracting having 360"* and *"looking around made me take in the information less"* and *"Sometimes I felt I had to look around, or you worry that you will miss something if you don't look."*

Some headset viewers complained of being forced to attend with the headset on, that they were constrained by the headset and they

could not get away from the presentation: *"so you can't wander off. In that way, you are physically made to pay attention"* and *"I tried to get away and then realised I can't because it's still there"* and *"you can't get away from it unless you close your eyes."*

One subject, a sufferer of Attention Deficit Hyperactivity Disorder, reported positively that it helped him to concentrate: *"Usually people with ADHD, they basically are, they need to work hard to focus on something, but I was basically in the video so there was ... nothing else distracting me around me."*

Others also reported to be more focussed than for example, the screen condition: *"I felt much more focused.. all your senses need to be engaged, wearing a headset your work is done it's there"* and *"I think maybe I took more in from what was being said in the headset."*

Some viewers, although enjoying the experience, were still relieved to take the headset off: *"...it's a relief to take it off and look at real things."* Another expressed a concern that it may not be good for you to watch over a long time, for example feature length movies. In fact most panoramic videos tend to be short, around the ten minute mark at the moment.

We can contrast these comments about using the headset with those using the phone. Many phone viewers also reported increased attention and interest: *"I focused more on how I had the chance to check around the video and move and yeah, so that's what really got my attention"* and *"I think it's much more successful because it gives you that space to kind of explore. I think it really works with the focus, I was definitely focused more on this."*

They also quite commonly reported being distracted by being able to look around in the video and distracted also by moving the phone around: *"I was more focused on what I was seeing but less focused on what he was saying"* and *"I can, in some ways lose focus because I'm just looking at something completely different."*

Both headset and phone viewers sometimes complained about transitions and jumps cuts used in the video. For example, as with regular video, a jump cut that occurs where the user is focussed on a subject but there is continuity with the position and pose of the subject in the new scene, can be acceptable without discomfort. However, when this is done in 360 video and the viewer is not looking at the subject, this can be jarring; if the user feels they are immersed in the scene, it can be the equivalent of instantly teleporting them to a new place without warning. Phone users complained for example: *"it was quite jarring to land in another shot"* and *"it is very disorientating when the camera changes angle or even changes the scene."*

Headset viewers sometimes reported seeing more detail than, for example, the phone condition where some complained of the screen being too small.

In the screen condition, by contrast, there were no issues reported with attention and focus. Instead, users report being really able to concentrate, finding it easier to focus, and being more focussed than, for example when using the phone: *"I felt more focused on the actual content this time"* and *"I was able to focus more on what he was saying and the topic in general"* and *"I was able to concentrate more."*

Screen users reported learning new things, that they understood the topic more than for example, using the phone, and that the format was better than the headset or phone for documentaries; also that not having the distraction of being able to look around they became more engaged: *"I thought this way was better if I was supposed to be focussing"* and *"It's still engaging and for specific types of videos, it's my preferred way of viewing them"* and *"if I'm just watching this kind of format (screen) just um for, I don't know, a TV drama or something like that, or an informative piece, then this is probably the format I would want to select."*

On the down side, screen users found the condition less interesting and exciting than the headset and that they found the view constrained (which in fact it was compared to the other two conditions): *"I prefer the other version (headset). It's definitely a less exciting experience"* and *"I felt less stimulated by the screen version"* and *"I didn't feel as engaged in the video as much as I did with the 3D [360] viewing."*

Screen users also complained about distortion in the image, which was a fair complaint as what they were seeing was a portion of the equirectangular view. This view (being the central 25 percent of the image) was chosen specifically as being the area showing least distortion, although distortion was still present. However, as we can see above this did not stop viewers being able to concentrate on and follow the video.

3.4. Freedom of View

For both the phone and headset conditions, users commented positively that they allowed the natural instinct to be able to look around. For the headset view particularly, the freedom to look around was both liberating and unsettling. Users reported being distracted by the environment: *"So keen to explore so you don't pay attention to what he said"* and *"if you spend the time looking at the guy over there, you're missing out what's happening at the back"* and *"At times my concentration was directly with it but then I'd find myself just looking around at other things too."*

Users also reported they were afraid they might miss something by looking in the wrong place, and that they are not sure where to focus: *"I was like, should I look at his face or should I look at what he is doing with his hands?"* and *"so I was confused; shall I look at that guy or shall I look at the other person."*

In fact, one editorial device that works fine in regular video, but does not necessarily work with 360 video, is that of the voice over. When watching a normal video, if a voice over follows a piece with a character or presenter talking, it is immediately obvious to the viewer that it is a voice over because they cannot see a presenter. However, in panoramic video, this does not work as well because the viewer needs to look around to see if there is a presenter or not and is generally uncertain whether one is present: *"it was quite hard to tell who was actually talking so whether he was actually talking on camera or whether it was a voice over."* Headset viewers specifically reported not paying attention to the narrative because of looking around: *"I'd find myself just looking around at other things"* and *"So keen to explore so you don't pay attention what he said."*

On the positive side, headset viewers reported being able to notice more looking around, and that videos have more repeat value in that they can be experienced differently each time, depending on where you look: *"So, the next time you look at it, if you change your point of view or you change your focus, you'd also experience it in a different way as well"* and *"you just notice, there's more things that you notice on the rift [Gear VR] than you do on the flat screen"* and *"What I really like about is that you can always experience that same video in a different way."*

For the phone condition, users commented favourably on being able to get different views and perspectives, that they had the choice of where to look, and consequently, they could see more: *"it gives you freedom to choose where to look"* and *"I get a sense of the environment."* However, phone viewers found it both difficult to orientate the phone at times and expressed difficulty in navigation. There were times when some users appeared to get lost and lose orientation when navigating by swiping on the phone: *"it was hard because you had no orientation in space cause you had no idea where you are in the space."*

For screen viewers, there was no freedom of view as they were given only one view. This was seen as positive in the sense that it was the normal way to watch video, however, screen viewers reported it to be less engaging than, for example, the headset: *"it's just normal, the way we watch it"* and *"A bit bored"* and *"You were more engaged when you had the headset on"* and *"I wasn't looking at the video and listening to the narrator as engaged as I was before."*

3.5. Limitations and issues

In general, users were pretty positive about viewing with a headset, but when asked, could point out many technical issues with both the headset and phone. Users reported the headset to be, at times, low resolution and not showing enough detail: *"The resolution was a bit low, it was quite annoying for me"* and *"I missed some of the fine detail you get on a high def-TV picture."*

Some users found that the screen in the headset was too close. Others reported eye strain from using the device. Some found actually wearing the headset to be uncomfortable: *"being up close to a screen and you have that feeling you don't blink as much, your eyes don't feel as comfortable afterwards"* and *"it's not particularly comfortable to wear."*

Some users wanted to be able to interact more. In particular, given the low resolution compared to normal video, users wanted the ability to zoom in and out. A further issue was that some users felt socially awkward wearing a headset in the presence of other people: *"I would like to be able to zoom in"* and *"I would find it quite weird to sit with a group of people with a headset strapped to my face."*

In contrast, phone viewers did not feel socially awkward when viewing videos and navigating by swiping, however, they did feel socially awkward when navigating the video by moving the phone around. Having different navigation techniques, rotating the phone around the viewer, tilting the phone to change view and navigation by swiping, were viewed positively. Some users said navigation

by swiping was easy, but others were confused by the navigation and forgot about swiping and only navigated by moving the phone around. Sometimes, physically moving the phone was awkward to do: *"I would feel self-conscious doing that if I was in a public space [moving phone] .. you can do that anywhere without being self-conscious [swiping]"* and *"It feels strange to move around. I wouldn't do it on a train."* and *"From the start I tried to move it about, but I found it easier after a while, just swiping through."*

Otherwise, phone users complained that the view sometimes appeared distorted, and that the screen size was too small: *"There's still a bit of weird distortion going on when things come close to the camera"* and *"if you slightly shift it to the right or left or you tilt it you can get perspective of that person, it can distort the perspective as well"* and *"it's a small screen so you have to, you can focus on only a small part of that spectrum."*

Screen viewers had much less to say about limitations, presumably because they are used to them in normal viewing. They found the view more limited than the headset and phone conditions; in fact it was reduced to the central twenty five percent of the equirectangular view. They also commented on issues with the distorted view and stitching. Indeed there was some distortion introduced by the view, but as only the centre of the equirectangular view was used, this was minimised. The creation of the 360 video involved shooting with six cameras and using software to stitch the videos together into one panorama and to correct errors arising from parallax. Some errors remained in the video, which were quite hard to spot for the headset and phone conditions, but were painfully obvious for the screen condition. So this was fair comment: *"This [screen] seems very constrained in what you can do."* and *"you could see distortion in a few parts of the video"* and *"when he moves from the side view to the central part of the screen, it distorts the objects"* and *"The stitching of the video was a lot more visible this way."*

3.6. Questionnaire results

After completing the two viewing conditions, subjects were asked to rate their responses to six questions on an Likert scale of five points ranging from agree 'not at all' to agree 'very much'. The responses to these questions (apart from question 5) are shown in figures 2 through to figure 6. The results per viewing platform were pooled to yield one graph per viewing platform per figure. As the numbers were too low for meaningful statistical analysis, we only report on the trends in the graphs in the following sections.

The first question asked about presence. It is clear from the graph that screen viewers' ratings cluster towards the 'not at all' end of the scale, while ratings produced by headset viewers cluster towards the agree end of the Likert scale with phone viewers' responses somewhere in between. This suggests that screen viewers had a lower sense of presence whereas headset viewers had quite a high sense of presence, with phone users falling somewhere in between. This agrees with the findings of the thematic analysis, but it is interesting that only half of the headset viewers in the analysis commented specifically on presence related issues, but in answering this question, fourteen, out of sixteen headset users responded as agreeing with the statement.

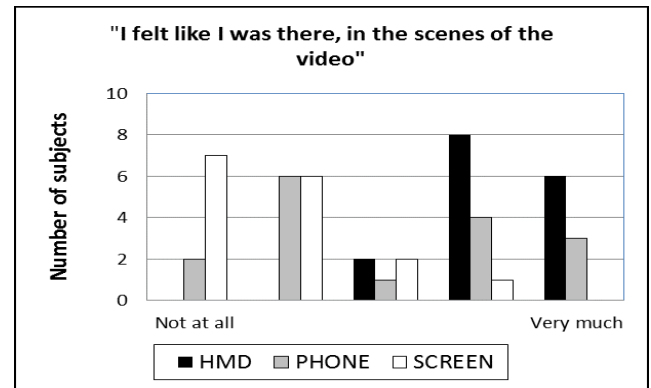


Figure 2: Responses to the statement "I felt like I was there, in the scenes of the video."

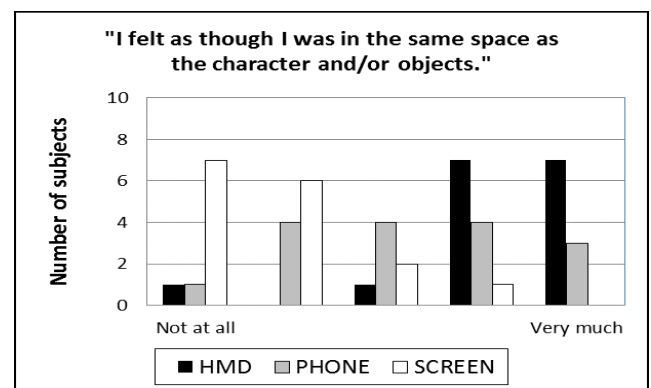


Figure 3: Responses to the statement "I felt as though I was in the same space as the character and/or objects."

The fourth question was also about presence. Not surprisingly, users had a similar response profile, with screen viewers clustering towards the 'not at all' end of the scale and the headset viewers clustered towards the agree end. Although this time one of them gave a rating of 'not at all' and another a rating in the indifferent middle position; again fourteen out of sixteen users agree with the statement. Again, phone viewers had a more even spread across the scale suggesting no majority view.

The second question asked about interaction, which was limited at best, to changing the view by moving the head in the case of the headset condition, and moving and tilting the phone or swiping to change view for the phone condition. There was no interaction for the screen condition, so it is not surprising to find viewers rated interaction towards the agree 'not at all' end of the scale. Users of the headset and phone were more positive, spreading their ratings across the scale, but the spread suggest there is no great sense of interaction for these viewing conditions.

The response to the question about attention showed that no viewer group disagreed strongly with this statement. Headset viewers were perhaps more enthusiastic than phone viewers, who were

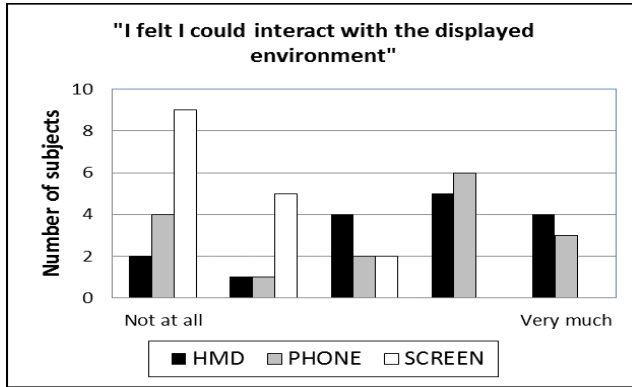


Figure 4: Responses to the statement "I felt I could interact with the displayed environment."

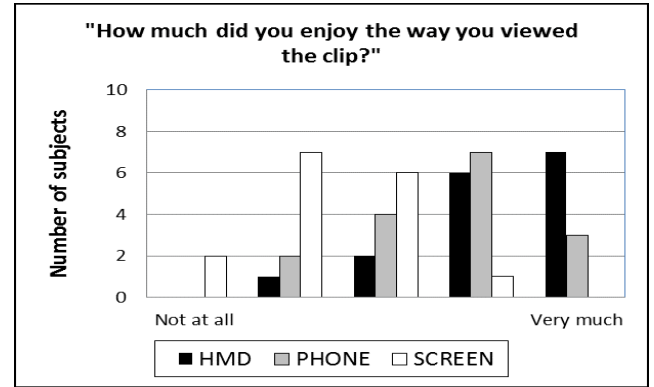


Figure 6: Responses to the question "How much did you enjoy the way you viewed the clip?"

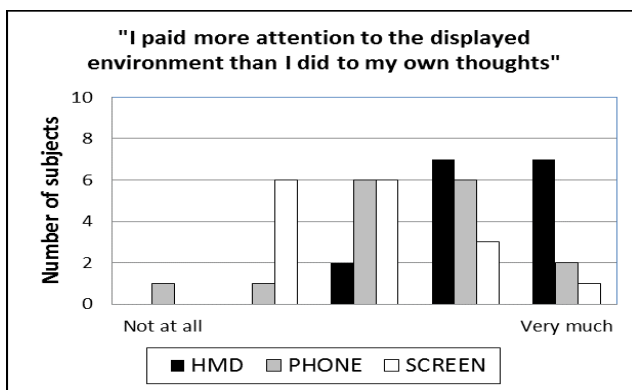


Figure 5: Responses to the statement "I paid more attention to the displayed environment than I did to my own thoughts."

perhaps more enthusiastic than screen viewers, but there were no strong differences shown in the graph.

It was of interest to distinguish between whether viewers liked the content or not, compared to how they viewed the content. As with much content, some people liked it and some did not, there did not seem to be a strong effect of viewing condition however (data not shown due to space limitations). With regards to the way user viewed the clips it seems headset users rated this most positively, followed by phone viewers and then screen viewers. This agrees with users' general enthusiasm for headset viewing expressed during the interviews.

4. Platform Response Profiles

In order to summarise the results at a high level, seven key themes were chosen to show the profile of users' typical responses to viewing content on the various platforms. The themes that most clearly distinguished the data were: presence, attention, engagement, concentration on story, certainty (about what should be attended to), comfort and social ease. A value, either low, medium, or high, was assigned for each condition for each theme and were plotted on the radar diagram in figure 7, thus yielding a profile for each viewing

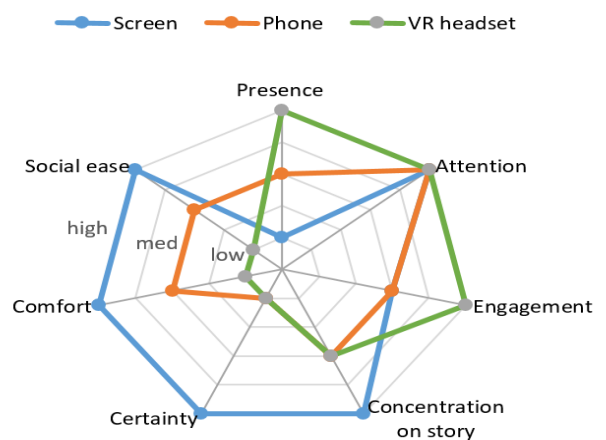


Figure 7: Viewer response profiles.

condition (values near the centre are low and increase away from the centre).

5. Discussion

It appears that panoramic video viewers currently have issues around attention; they do not report being able to concentrate as well as viewers of regular video, may be distracted by their environment and unsure where to be looking or what to attend to. The profile shows a high sense of presence for the headset condition, but it is low for the screen condition. Attention is high for both conditions, but they vary on engagement with participants reporting higher levels of engagement for the headset compared to the screen condition. However, although headset users may be more engaged, they reported concentrating less on the story and were much more uncertain about what they should attend to compared to screen users. The differences then, in terms of concentration on story and uncertainty, are the issues that storytelling has to resolve to be effective in panoramic video. With respect to physical issues, a challenge to content makers is also that headset users reported

lower comfort levels and were much more likely to be socially uneasy, with respect to being in the actual world while viewing, compared to screen users. Phone users fell somewhere between these two profiles. Perhaps in time, content creators will develop a language which allows the viewer to be comfortable in consuming 360 video; in that like with much traditional video, the director gives sufficient cues for the viewer to be confident in their viewing experience. Alternately, perhaps the content for panoramic video needs to be tailored to accommodate the viewer experience. One thing that seems clear for the moment is, if you really want audiences to follow an exact presentation, then consider a traditional television format.

The applicability of panoramic video may well vary from genre to genre, for example looking at the rash of upcoming horror pieces; the horror genre seems to be ideally suited for 360 video as it aims to unsettle and disturb. While it is early days for both content creators and viewers in understanding what can be done with panoramic video, we can make some suggestions based on our results for situations which are best suited for panoramic video. For example, situations where you might get unique perspectives, users found it quite compelling when there was a close-up on the Bee man's hands and electronics while making music. Panoramic video seems particularly well suited to situations where the viewer can explore and look around at own their pace, much as they might do in a gallery, or a crowded market situation, where the experience is user led rather than led by a director. This may mean making content with an ambient feel, rather than trying to dictate a narrative, or making semi interactive pieces where the user can interactively progress the story rather than having to go at a fixed pace. Given that users reported a sense of presence, transporting them to places they might not otherwise go is obviously appealing. The possibility of new genres is particularly intriguing; perhaps panoramic video will be well suited to situations where audio narrative and video can be loosely coupled, such as providing ambient imagery for radio documentaries etc. Users themselves probably mentioned documentary as being the best suited genre for panoramic video, but over the study mentioned virtually all genres.

6. Conclusions

This a challenging time for content producers who are witnessing the rapid convergence of television, the internet, computer games and consumer devices such as mobile phones, and in the current wave of technology, consumer level virtual reality headsets. Panoramic video is just one point in this space where new challenges and opportunities arise for them. In order to inform content production, in this study we have looked at the user experience of panoramic video, considering the ways in which users may consume such content now, and comparing the different viewing platforms. Through a comprehensive thematic analysis, we identified seven major themes around the user experience of such technology in order to profile user responses. In future work, we will explore these further and investigate other viewing scenarios.

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